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Effects of sleeve gastrectomy surgery on electrocardiographic ventricular arrhythmia markers

Sleeve gastrectomy and electrocardiogram

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Abstract
Aim: Severely obese patients are known to be at risk of malignant arrhythmias. The frequency of ventricular arrhythmia and sudden death is increasing in morbidly obese patients. Ventricular depolarization and repolarization parameters on the electrocardiogram can predict mortality and morbidity. Electrocardiographic (ECG) markers of ventricular depolarization and repolarization parameters like QT, QTc, QTd, QTdc, JT, JTc and Tp-e intervals and Tp-e/QT, Tp-e/QTc, Tp-e/JT and Tp-e/JTc ratios were evaluated before and after sleeve gastrectomy surgery.
Material and Methods: ECG recordings of 35 (24 females and 11 males) morbid obese patients without evident cardiovascular disease were analyzed before and 20.3±9.6 (6-36) months after sleeve gastric surgery. QT, QRS, JT, and Tp-e intervals were measured. QTc, QTd, QTdc, and JTc intervals and Tp-e/QT, Tp-e/QTc, Tp-e/JT and Tp-e/JTc ratios were calculated.
Results: Body mass index (48.29±7.65 to 31.38±4.94 kg/m2, p<0.001), QTc interval (405.6±17.3 to 389.2±16.6 milisecond (ms), p<0.001), QTd (27.5±12.4 to 18.3±9.0 ms, p<0.001), QTdc (30.7±14.4 to 19.1±9.1 ms, p<0.001), JTc interval (315.0±19.0 to 301.2±20.4 ms, p=0.001), Tp-e interval (81.6±7.8 to 69.5±9.3 ms, p<0.001), Tp-e/QT ratio (0.22±0.03 to 0.19±0.02, p<0.001), Tp-e/QTc ratio (0.20±0.02 to 0.18±0.02, p<0.001), Tp-e/JT ratio (0.29±0.04 to 0.24±0.03, p<0.001) and Tp-e/JTc ratio (0.26±0.03 to 0.23±0.03, p<0.001) were significantly decreased after sleeve gastrectomy surgery.
Discussion: QTc, QTd, QTdc, JTc, and Tp-e intervals and Tp-e/QT, Tp-e/QTc, Tp-e/JT and Tp-e/JTc ratios, which are potential ECG ventricular arrhythmia predictors were significantly decreased. Therefore weight reduction with sleeve gastrectomy surgery may be associated with decreased malign arrhythmia tendency and sudden cardiac death.

Keywords
Morbid Obesity, Sleeve Gastrectomy Surgery, Tp-e Interval, Tp-e/JTc Ratio, Ventricular Arrhythmia

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Introduction

The frequency of obesity is increasing throughout the world, and its association with various comorbid conditions makes it one of the most critical health problems at present [1]. The American College of Cardiology guidelines consider morbid obesity as a body mass index (BMI) of ≥40.0 kg/m2 [2].

Severely obese patients are known to be at risk of malignant arrhythmias and reduced life expectancy [3]. Abnormalities during ventricular depolarization, and especially during ventricular repolarization, may cause lethal ventricular arrhythmias and sudden cardiac death (SCD) [4]. Obesity is also known to be related to prolonged QTc, JTc, and Tp-e, which are 12-lead electrocardiographic (ECG) markers for ventricular depolarization or repolarization [5]. The impacts of obesity and weight reduction on QT, QTc, and QTd have been evaluated in a relatively large amount of studies; [5] however, data about the effects of sleeve gastrectomy surgery (SGS) or weight loss on JTc and Tp-e are scarce [5]. In comparison with the QTd and Tp-e intervals, the Tp-e/QT ratio has been reported to be more specifically related to ventricular arrhythmias [6]. According to our review of the literature, there is no other study investigating the Tp-e/QT, Tp-e/QTc, Tp-e/JT, and

Tp-e/JTc ratios in morbidly obese subjects undergoing SGS.

Bariatric surgery has become an acceptable treatment modality for morbid obesity, and SGS is becoming the predominantly performed bariatric procedure. The sleeve's safety and the procedure's long-term weight loss results have been widely proven [7].

This study aims to explore the alterations in ventricular repolarization parameters after SGS.

Material and Methods

Study population

Approval for the study was obtained from the Local Ethics Committee, and the study was planned retrospectively (Date: October 14, 2019. Decision number: 2019/222). Thirty-five morbidly obese subjects (24 female, 11 male) who had undergone SGS were included. The 12-lead ECGs of the patients were examined before and 20.3±9.6 (6-36) months after SGS.

Subjects having a history of atherosclerotic cardiovascular disease, significant valvular disease, heart failure, liver or renal failure, chronic lung disease, severe obstructive sleep apnea, and electrolyte imbalances were excluded. Subjects having a history of ventricular arrhythmias, left-axis deviation, atrial fibrillation, and hypertrophic findings were also excluded for the likely impacts of these ECG variations on the calculated ECG parameters.

Electrocardiography

A 12-lead ECG with 25 mm/s speed, 10 mm/mV amplitude, and standard lead positions (Nihon Kohen Cardiofax ECG-1950 VET) was used in the study. The ECG parameters were measured manually with the TorQ 150 mm digital caliper LCD device by cardiologists blinded to each other (Figure 1). QTc, QTdc, and JTc were computed using Bazett's formula ($QTc = QT/\sqrt{RR}$) [8]. Additionally, Tp-e/QT and Tp-e/QTc ratios were calculated. The intraobserver and interobserver differences for analyses were less than 5%.

Statistical analysis

SPSS software was used for statistical analysis (SPSS 22.0 for Windows, IBM Co, Chicago, IL, USA). The Kolmogorov-Smirnov test determined the distribution normality, while the standard variables were compared with a t-test and represented as mean ± standard deviation. The Mann-Whitney U test was used for variables showing an abnormal distribution and expressed as median (IQR: interquartile interval), and a chi-squared test was used to compare the nonparametric variables. The changes in parameters after surgery were correlated with paired t-tests. A p-value of less than 0.05 was considered statistically significant.

Results

BMI and the frequencies of hyperlipidemia, hypertension, diabetes, and current smoking status were significantly decreased after SGS (Table 1). BMI and heart rate were significantly reduced during follow-up (48.29±7.65 to 31.38±4.94 kg/m2, p<0.001, 74.2±6.6 to 67.0±10.3 bpm, p=0.001, respectively). The ECG parameters were significantly shortened/decreased after sleeve gastric surgery:

- QTc interval: 405.6±17.3 to 389.2±16.6 ms, p<0.001
- QTd interval: 27.5±12.4 to 18.3±9.0 ms, p<0.001
- QTdc interval: 30.7±14.4 to19.1±9.1 ms, p<0.001
- JTc interval: 315.0±19.0 to 301.2±20.4 ms, p=0.001
- Tp-e interval: 81.6±7.8 to 69.5±9.3, p<0.001
- Tp-e/QT ratio: 0.22±0.03 to 0.19±0.02, p<0.001
- Tp-e/QTc ratio: 0.20±0.02 to 0.18±0.02, p<0.001
- Tp-e/JT ratio: 0.29±0.04 to 0.24±0.03, p<0.001
- Tp-e/JTc ratio: 0.26±0.03 to 0.23±0.03, p<0.001 (Table 2).

Table 1. Baseline and postoperative follow-up characteristics of the study group

Baseline characteristics	Before surgery	After surgery	P value
Age (years)	40.3±7.8	41.3±7.8	0.593
Male/female	11.24	11.24	1.000
Hypertension (%)	13 (37.1%)	4 (11.4%)	0.012
Smoking (%)	8 (22.9%)	2 (5.7%)	0.041
Diabetes mellitus (%)	14 (40%)	3 (8.6%)	0.002
Hyperlipidemia (%)	10 (28.6%)	0 (0%)	<0.001
BMI (kg/m2)	48.29±7.65	31.38±4.94	<0.001
HbA1c (%)	5.8±1.1	5.2±0.6	0.016

BMI: Body mass index

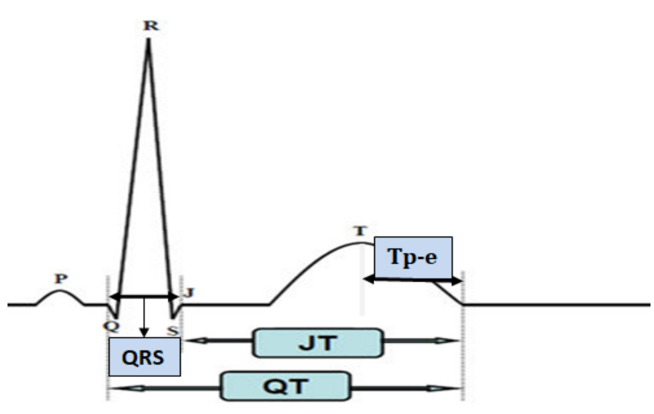

Figure 1. Representation of ECG parameters on surface ECG.

Table 2. Electrocardiographic findings of the study population

	Before surgery	After surgery	P value
Heart rate (bpm)	74.2±6.6	67.0±10.3	0.001
QT ms	365.9±21.1	371.9±28.6	0.295
QTc ms	405.6±17.3	389.2±16.6	<0.001
QTd ms	27.5±12.4	18.3±9.0	<0.001
QTdc ms	30.7±14.4	19.1±9.1	<0.001
JT ms	283.9±22.2	287.9±33.3	0.492
JTc ms	315.0±19.0	301.2±20.4	0.001
Tp-e ms	81.6±7.8	69.5±9.3	<0.001
Tp-e/QT	0.22±0.03	0.19±0.02	<0.001
Tp-e/QTc	0.20±0.02	0.18±0.02	<0.001
Tp-e/JT	0.29±0.04	0.24±0.03	<0.001
Tp-e/JTc	0.26±0.03	0.23±0.03	<0.001

Bpm: beat per minute, ms: millisecond, QT interval: from the beginning of the QRS complex to the end of the T wave, QTc: Corrected QT interval, QTd: QT dispersion, QTdc: Corrected QT dispersion, JT interval (JT): The distance from the end of the QRS interval (point J) to the end of the T wave, JTc: Corrected JT interval, Tp-e: T peak and end interval.

Discussion

In our study, we found that QTc, QTdc, JTc, and Tp-e intervals and their ratios were significantly decreased after SGS. The ECG parameters evaluated were indirect arrhythmia measures: the frequencies of hypertension, hyperlipidemia, diabetes, and smoking rates increase in obesity. These conditions may affect depolarization and repolarization parameters.

Ventricular tachyarrhythmias leading to SCD may occur even in obese individuals without heart disease. Consequently, it is essential to discriminate possible real predictors of such malign lethal arrhythmias. The 12-lead ECG is a secure and commonly used technique that can provide critical data for this aim. Myocardial repolarization indices were assessed, including QT, JT, and Tp-e intervals. It was necessary to correct the QT and JT by the subject's heart rate.

Prolongation in QT and QTc intervals and QTd have been linked with increased ventricular arrhythmia and SCD risk, [9] while obesity has been linked with prolonged QT and QTc intervals and QTd [10]. QTc has been reported to be shortened after surgery-induced weight loss [5, 11]. Our study showed that there was a significant decrease in QTc and QTd after SGS.

Cardiac electrical changes during ventricular repolarization may also result in malignant arrhythmias [12]. JT intervals correspond to the ventricular repolarization period in contrast to QT intervals, which correspond to both depolarization and repolarization [13]. Similar to our results, Russo et al. reported a significant reduction in QTc, JTc, and Tp-e values after bariatric surgery-induced weight loss [5]. In ECG readings, the interval between the peak and the end of the T wave is called the Tp-e interval. While the Tp-e range may represent the total distribution of repolarization, [14] Tp-e has been linked with increased arrhythmias and SCD, even in cases with normal QTc [15, 16]. According to our literature review, apart from Russo et al. [5] there are no other studies evaluating Tp-e in weight loss or SGS.

The Tp-e/QT ratio is also related to fatal arrhythmias. Remarkably, it remains comparatively stable at heart rates of 60-100 bpm, [17] making this ratio potentially more sensitive than Tp-e and QT intervals for arrhythmia prediction [6, 18]. However, since Tp-e reflects ventricular repolarization alone, the Tp-e/JT ratio can be a more specific indicator than the Tp-e/QT ratio. Unfortunately, no data were found regarding this issue. In a small study examining the indices of ventricular repolarization between healthy subjects and patients with previous myocardial infarction, the specificity, and sensitivity of the Tp-e / JT ratio were 100% and 94%, respectively [19]. Most investigations evaluating obese patients have utilized the QTc and QTd intervals; however, JT, JTc, and Tp-e intervals and Tp-e/QT ratio are rarely used in this aspect [11]. This study's findings show that the QTc, JTc, and Tp-e intervals and the Tp-e/QTc and Tp-e/JTc ratios decreased after SGS. We hope that future studies will confirm the clinical significance of these findings, which could help to predict fatal malignant arrhythmias.

Hypertension and diabetes are among the comorbid conditions associated with obesity. They have also been related to prolonged ventricular depolarization and repolarization indices [20]. As in our study, weight reduction has been associated with decreased frequencies of diabetes and hypertension [21]. Smoking has been reported to cause SCD due to the disturbance of repolarization parameters in ECGs [22]. Therefore, the elimination or improvement of such comorbid conditions after weight loss may also contribute to our finding of improvement in ventricular arrhythmia predictors after SGS.

This study demonstrates that the heart rate is reduced after surgery. This may be due to decreased activity of the sympathetic nervous system after surgery [23].

Limitation

The small sample size and the manual calculation of measurements are significant limitations. Automated analysis systems have improved QT measurement, but there are also issues with this process [24]. Since a manual analysis of the T-end is inadequately reproducible, automated methods may be preferred [25]. Additionally, we did not include a control group for observing the effects of factors such as pharmacotherapy and lifestyle changes (diet, physical activity) on the repolarization parameters.

Conclusion

This study found that QTc, QTdc, JTc, and Tp-e intervals and their ratios, which are markers of ventricular depolarization and repolarization on surface ECG, are significantly decreased after SGS. Therefore, weight reduction with SGS may be associated with a decreased malign arrhythmia tendency and sudden cardiac death. Future prospective studies will be valuable to confirm our results.

Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest
None of the authors received any type of financial support that could be considered

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